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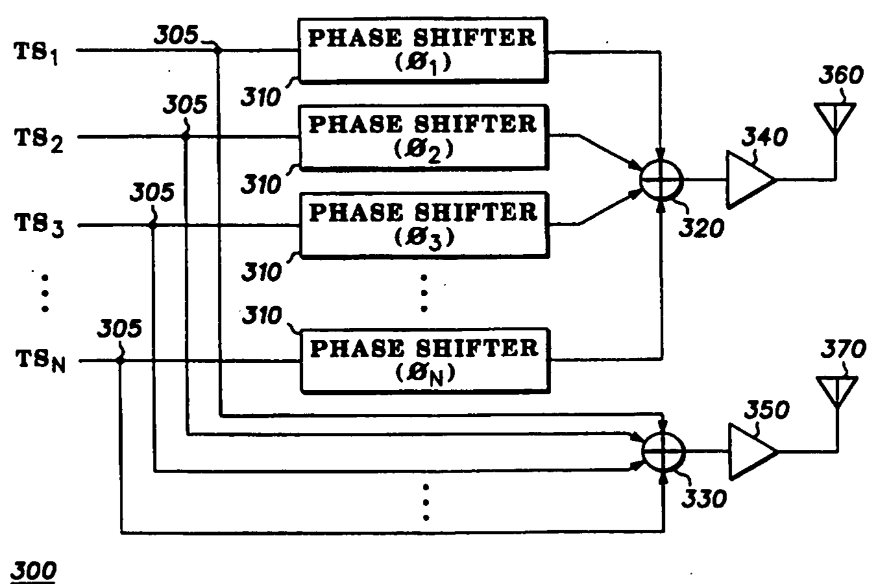

(57) Abstract

A satellite communications system employs CDMA multiple access technology. Polarizations are associated with each spreading code to enhance separation between simultaneous users in the absence of perfectly orthogonal spreading codes. A satellite transmitter CDMA encodes (210) and carrier modulates (220) a user or block of users, and then assigns a polarization to the user of block or block of users. A CDMA reference signal also receives a polarization. A ground receiver (30, 40) receives the polarized CDMA signals as transmitted by the satellite. The ground receiver ascertains the polarization of the reference signal and then computes the polarization of the desired polarized CDMA signal. The use of the reference signal negates the effects of the Faraday rotation caused by the satellite signal (10, 20) passing through the ionosphere.

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SYSTEM AND METHOD USING POLARIZED CDMA SIGNALS

Field of the Invention

This invention relates in general to satellite communications, and in particular, to polarized CDMA satellite communications.

Background of the Invention

Satellites employed in satellite communication systems typically must communicate with multiple users simultaneously. Typical methods for multiplexing multiple users are TDMA, FDMA, and CDMA.

CDMA, or Code Division Multiple Access, allows for multiple users through the use of spread spectrum techniques which assign different spreading codes to different users. If all the spreading codes are perfectly orthogonal, then when each user de-spreads his signal using his code, there is no interference contributed by the other users' signals. In practice, pseudo-random spreading codes are used, which are not completely orthogonal. Because of the non-orthogonality of commonly used spreading codes, or otherwise imperfect synchronization with orthogonal codes, multiple users in a satellite communication system employing CDMA necessarily cause interference in each other's communications.

As the number of users communicating with a single satellite increases, the interference increases and the quality of communications drops. The quality of communications and the capacity of the system, as measured by the number of possible

simultaneous users, are important performance measures of a satellite based communication system.

Accordingly, there is a great need for a system and method for reducing the interference between users and thus increasing the available capacity of the system and improving the quality of communications.

Brief Description of the Drawings

The invention is pointed out with particularity in the appended claims. However, other features of the invention will become more apparent and the invention will be best understood by referring to the following detailed description in conjunction with the accompanying drawings in which:

FIG. 1 shows a satellite communication system with multiple users in accordance with an embodiment of the present invention;

FIG. 2 shows a diagram of a satellite transmitter in accordance with a preferred embodiment of the present invention;

FIG. 3 shows a diagram of a polarization network and antenna subsystem for a satellite transmitter in accordance with a preferred embodiment of the present invention;

FIG. 4 shows a diagram of a satellite receiver in accordance with a preferred embodiment of the present invention;

FIG. 5 shows a diagram of an antenna subsystem and polarization network for a satellite receiver in accordance with a preferred embodiment of the present invention;

FIG. 6 shows a diagram of a ground receiver in accordance with a preferred embodiment of the present invention;

FIG. 7 shows a diagram of a ground transmitter in accordance with a preferred embodiment of the present invention;

FIG. 8 shows a flow chart for a method of operating a satellite transmitter in accordance with a preferred embodiment of the present invention; and

FIG. 9 shows a flow chart for a method of operating a ground receiver in accordance with a preferred embodiment of the present invention.

Detailed Description of the Drawings

Generally, the present invention helps mitigate the problem of multiple users causing interference to each others' communications in a CDMA system. In accordance with a first embodiment of the present invention, the apparatus includes a transmitter for transmitting polarized CDMA signals. A polarization network receives a plurality of CDMA signals and an antenna subsystem coupled to the polarization network transmits the polarized CDMA signals.

In accordance with another embodiment of the present invention, the apparatus includes a receiver for receiving polarized CDMA signals. An antenna subsystem receives polarized CDMA signals and a polarization network coupled to the antenna subsystem de-polarizes the polarized CDMA signals.

In accordance with another embodiment of the present invention, the apparatus includes a receiver for receiving a

polarized CDMA signal. The receiver includes an antenna subsystem, a polarization network coupled to the antenna subsystem, means for de-spreading the polarized CDMA signal, means for determining an absolute polarization of the polarized CDMA signal, and means for modifying the polarization network in response to the absolute polarization of the polarized CDMA signal.

In accordance with another embodiment of the present invention, a method of operating a transmitter for transmitting polarized CDMA signals is provided. The method includes the steps of CDMA encoding a number of signals to produce a number of CDMA encoded signals, assigning polarization values to each of the number of CDMA encoded signals, and transmitting the CDMA encoded signals at their respective polarizations.

In accordance with another embodiment of the present invention, a method of operating a receiver for receiving a polarized CDMA signal is provided. The method includes the steps of detecting a reference signal as transmitted, measuring the polarization of the reference signal, determining the polarization of the polarized CDMA signal, modifying a polarization network to increase reception of the polarized CDMA signal, and de-spreading the polarized CDMA signal.

FIG. 1 shows a satellite communication system with multiple users in accordance with an embodiment of the present invention. The satellite communication system includes satellite 50 which communicates with ground based users 30 and 40 with signals 10 and 20 respectively. Satellite 50 can be in one of many different types of orbits, preferably a geosynchronous orbit.

Users 30 and 40 represent two users out of a potentially very large number of users. The users in the satellite communication system of the present invention can be mobile, transportable or fixed. They are preferably in a fixed orientation when operating. User 30 communicates with satellite 50 via the signal 10, a CDMA signal which is spread using a code unique to user 30. Likewise, user 40 communicates with satellite 50 via signal 20, a CDMA signal spread using a code unique to user 40. As previously discussed, users 30 and 40 typically employ spreading codes that do not exhibit complete orthogonality and thus interfere with each other.

To mitigate the interference, a preferred embodiment of the present invention employs polarization techniques for signals 10 and 20. As will be discussed in more detail below, the CDMA signal carriers transmitted to users 30, 40, and others not shown, are polarized so that each user will contribute reduced interference to all others.

Linear polarization of signals in free space is a known method for allowing multiple separate communications using a single carrier. For example, a first signal may be vertically polarized using a carrier, and a second signal may be horizontally polarized using the same carrier. As long as the two users have complete orthogonality in their polarizations, they can be separated at a receiver. As the number of users increases beyond two however, perfect orthogonality is no longer possible. Each user added beyond two in a linearly polarized system will interfere with other users, if linear polarization is the only multiple access technique employed.

The method and apparatus of the present invention combines the use of CDMA multiple access technology and polarized carriers to enhance separation between users in the absence of complete orthogonality in spreading codes. The enhanced separation in turn decreases interference for each user as contributed by other users. Decreased interference results in increased quality of communications, and allows the satellite based communication system to increase capacity as measured by the number of simultaneous users.

Of course, the use of polarized CDMA carrier signals is not limited to satellite communication systems, but is widely applicable to a variety of possible communication systems. The method and apparatus of the present invention is therefore not limited to satellite communications. One of the many other possible uses is in the area of terrestrial CDMA networks, and especially networks which have unobstructed line-of-sight (LOS) communications between transmitters and receivers. Terrestrial CDMA networks can benefit greatly from the improved quality of communications and increase in system capacity as provided by the present invention.

Satellite Transmitter

FIG. 2 shows a diagram of a satellite transmitter in accordance with a preferred embodiment of the present invention. FIG. 2 shows multiple transmit data streams designated TD_1 through TD_N, where N can be any number. The transmit data streams are each encoded with a separate pseudo-random code in CDMA coding blocks 210. After CDMA coding, the signals are up-converted in frequency conversion blocks 210 resulting in transmit signals shown in FIG. 2 as TS_1 through TS_N. The transmit signals are then input to the polarization network and antenna subsystem 300. As will be discussed in more detail below, polarization network and antenna subsystem 300 transmits the transmit signals at different polarizations.

Each transmit data stream represents the data from a single user, or alternatively, data from multiple users. In the case of a single user, CDMA coding block 210 employs a single spreading code to spread the transmit data from the single user. In the case where the transmit data stream represents data from multiple users, CDMA coding block 210 spreads each of the data streams with a separate spreading code. Each frequency conversion block 220 then, has as an input, CDMA encoded data streams from one to many users. The output of frequency conversion block 220 can be at one of many possible frequencies, including an IF frequency, but is preferably at the transmit frequency. Each signal denoted by TS then, represents from one to many CDMA encoded data streams up-converted to a carrier

frequency. By combining multiple users into a single frequency conversion block, and by polarizing each transmit signal TS differently, multiple users can be assigned the same polarization value.

Polarization network and antenna subsystem 300 receives each transmit signal, polarizes each with a different polarization, combines the polarized waveforms, and transmits the resulting composite CDMA signal. Since each transmit signal has received a different polarization value, each user or block of users receiving the resulting composite CDMA signal can take advantage of the polarized transmission to increase the signal quality as received. Increasing the signal quality provides for many advantages, as previously discussed.

Polarization network and antenna subsystem 300 is realizable in a number of possible topologies, but a preferred embodiment is discussed in reference to FIG. 3 below.

FIG. 3 shows a diagram of a polarization network and antenna subsystem for a satellite transmitter in accordance with a preferred embodiment of the present invention. Polarization network and antenna subsystem 300 includes signal splitting devices 305, phase shifters 310, signal summing devices 320 and 330, amplifiers 340 and 350, and antenna elements 360 and 370.

The polarization network and antenna subsystem 300 receives CDMA signals as inputs. The CDMA signals are the transmit signals TS_1 through TS_N. The CDMA signals are split at signal splitting devices 305, each into two separate but identical components. Signal summing device 330 sums in-phase components of each CDMA signal and provides the resulting

waveform to amplifier 350. Amplifier 350 drives antenna element 370 so that the resulting transmit waveform includes in-phase components of each CDMA signal.

Copies of the CDMA signals as output by signal splitting devices 305 are also each fed to a phase shifter 310. Phase shifters 310 have a fixed phase shift, or alternatively, a programmable phase shift. In the preferred embodiment being set forth, the phase shifters have a variable phase shift designated by F_1 through F_N. The phase shifted CDMA signals as output by phase shifters 310 are summed at signal summing device 320, producing a sum of phase shifted CDMA signals which are then input to amplifier 340. Amplifier 340 drives antenna element 360 which results in a transmitted waveform containing phase shifted CDMA signals.

Antenna elements 360 and 370 are physically oriented such that they have different polarizations. Any orientation which results in antenna elements 360 and 370 having an orthogonal component is contemplated, but antenna elements 360 and 370 are preferably completely orthogonal. In the preferred embodiment, antenna element 360 is vertically polarized and antenna element 370 is horizontally polarized, although they could be differently polarized.

Amplifiers 340 and 350 are shown driving antenna elements 360 and 370 because customarily this is the point where amplifiers reside in such systems. However, it will be readily understood by one skilled in the art that amplifiers can be located throughout the transmitter system.

In operation, phase values F_1 through F_N are chosen to maximize the separation between users. If, for example, only two users existed, a first user could be assigned to transmit signal TS_1 and F_1 could be 0 degrees. The second user could be assigned to transmit signal TS_2 and phase value F_2 could be 90 degrees. With only two users, polarizations 90 degrees apart maximizes the separation between users. In a like manner, if three users were present in the system, each could be assigned to a separate transmit signal and the corresponding phase values could be 45 degrees apart, thereby enhancing the separation of the three users. As the number of users increases, they are assigned to different transmit signals and the phase values are adjusted to attempt to maximize the polarization differences between existing users.

This system, which attempts to maximize the polarization difference between users, provides a very robust method of increasing communication quality for each user, and in turn, for increasing the capacity of the system.

In the preferred embodiment, a reference signal which is easily detected by all users in the system is assigned to one of the transmit signals and the phase value used in the corresponding phase shifter 310 becomes a reference phase value. The reference phase value can take on any phase value, but is preferably 0.

Because all of the polarized CDMA waveforms as transmitted by antenna elements 360 and 370 travel from the satellite through the ionosphere and to the ground, they all experience the same faraday rotation, or more simply stated, the

same change in polarization. The inclusion of a reference waveform allows all other CDMA signals to have polarization values which are measured relative to the polarization value of the reference signal. Polarization relative to a reference polarization allows the system to operate regardless of the faraday rotation caused by the ionosphere.

The apparatus and methods of the present invention can be advantageously used in a variety of frequency bands, but because the effects of faraday rotation become less pronounced at higher frequencies, the present invention preferably operates at Ka band or above.

Satellite Receiver

FIG. 4 shows a diagram of a satellite receiver in accordance with a preferred embodiment of the present invention. The satellite receiver includes antenna subsystem and polarization network 500, frequency conversion blocks 420, and CDMA decoding blocks 410. The satellite receiver as shown in FIG. 4 is recognizable as very similar to the satellite transmitter of FIG. 2, with the main difference being the direction of the signal flow.

Antenna subsystem and polarization network 500, which will be discussed in more detail below, receives polarized signals, removes the effect of polarization, or de-polarizes the CDMA signals, and produces received signals labeled RS_1 through RS_N in FIG. 4. Each received signal is input to a frequency conversion block 420 which down-converts the signal. The down-converted signal is then input to CDMA decoding block 410.

CDMA decoding block 410 de-spreads the CDMA encoded signals and produces received data streams RD_1 through RD_N. Each received data stream represents from one to many user data streams. In the case of multiple user data streams, CDMA decoding block 410 de-spreads multiple CDMA encoded streams using multiple pseudo-random codes.

Antenna subsystem and polarization network 500 could be any antenna subsystem and polarization network capable of receiving signals at multiple polarizations and removing the effects of polarization from each signal. A preferred embodiment of antenna subsystem and polarization network 500 is set forth below.

FIG. 5 shows a diagram of an antenna subsystem and polarization network for a satellite receiver in accordance with a preferred embodiment of the present invention. Antenna subsystem and polarization network 500 includes antenna elements 560 and 570, amplifiers 540 and 550, signal splitting devices 520 and 530, phase shifters 510, and signal summing devices 505. Analogous to the transmit antenna elements shown in FIG. 3, antenna elements 560 and 570 of the satellite receiver have orthogonal components. Antenna element 560 is preferably a vertically polarized antenna and antenna element 570 is preferably a horizontally polarized antenna, although they could be differently polarized. Amplifiers 540 and 550 are shown as low noise amplifiers at the antenna feed points, but one skilled in the art will appreciate that amplifiers may appear throughout the receiver system.

The signal which is output from amplifier 540 and present at signal splitting device 520 represents the polarized component of the CDMA signals as received by antenna element 560. For example, in the preferred embodiment with antenna element 560 vertically polarized, the signals present at signal splitting device 520 represent the vertically polarized component of each of the polarized CDMA signals as received by antenna element 560. Likewise, the signals present at signal splitting device 530 represent the polarized components of the CDMA signals as received by antenna element 570. In the preferred embodiment, with antenna element 570 being horizontally polarized, the signals present at signal splitting device 530 are the horizontally polarized components of the polarized CDMA signals as received by antenna element 570.

Signal splitting device 520 outputs N copies of the polarized component CDMA signals. Each of these signals is then passed through a phase shifter 510 resulting in N phase shifted polarized component CDMA signals. Each phase shifter 510 can have a fixed phase shift, but preferably has a programmable phase shift designated by F_1 through F_N.

Signal splitting device 530 produces N copies of the polarized component CDMA signals as received by antenna element 570. Each of these signals is then combined at signal summing devices 505 with the phase shifted polarized component CDMA signals as output by phase shifters 510. The output of signal summing devices 505 are the de-polarized received CDMA signals represented by RS_1 through RS_N.

Because of the polarization of the signals as received by the antenna elements, the received CDMA signals RS_1 through RS_N interfere with each other considerably less than in a non-polarized CDMA system. As previously discussed with reference to the satellite transmitter, this decreased interference results in a number of advantages, including increased capacity and increased quality of communications.

Ground Receiver

FIG. 6 shows a diagram of a ground receiver in accordance with a preferred embodiment of the present invention. The ground receiver includes antenna subsystem 610, frequency conversion block 670, CDMA decode block 680, and processor 690. Antenna subsystem 610, in turn, includes antenna elements 620 and 630, phase shifter 640, signal summing device 650 and amplifier 660.

The ground receiver operates very much like the satellite receiver with the exception that in general, a smaller number of polarized CDMA signals is being received. Antenna subsystem 610 receives the polarized CDMA signals as transmitted by the satellite, which are then input to frequency conversion block 670. Frequency conversion block 670 down-converts the signal and CDMA decode block 680 de-spreads the signal to produce a data stream. As in the case of the satellite receiver, the data stream output by CDMA decode block 680 represents data from one to multiple users. In the case of multiple users, CDMA decode block 680 de-spreads each user's data with a different pseudo-random code.

Antenna subsystem 610 could be any antenna subsystem capable of receiving a polarized signal. As shown in FIG. 6, the preferred embodiment of antenna subsystem 610 includes two antenna elements 620 and 630, phase shifter 640, signal summing device 650, and amplifier 660. Antenna elements 620 and 630 have an orthogonal component and in the preferred embodiment being set forth, antenna element 620 is vertically polarized, and antenna element 630 is horizontally polarized, although they could be differently polarized. Antenna element 620 receives the polarized CDMA signals as transmitted by the satellite, and feeds them to phase shifter 640. The phase shifter 640 is controllable by processor 690, so that the ground receiver is capable of receiving signals at any possible polarization. The output of phase shifter 640 is summed at signal summing device 650 with the polarized component CDMA signal as received by antenna element 630. The resulting sum is then amplified by amplifier 660, and then passed on to frequency conversion block 670.

The inclusion of processor 690 allows for the control of phase shifter 640 to increase reception of the desired polarized CDMA signal. Because the polarized CDMA signals have undergone faraday rotation while passing through the ionosphere, the ground receiver may first have to acquire the reference signal, and then modify the phase shifter so that the desired polarized CDMA signal is acquired. Once the desired polarized CDMA signal is acquired, processor 690 can periodically obtain quality measurements as provided by CDMA decode block 680 and incrementally adjust phase shifter 640 to compensate for any changes in polarization. One skilled in the art will appreciate

that processor 690 provides a control function which can be implemented in a multitude of fashions, including dedicated digital hardware, or a combined digital and analog control loop.

Ground Transmitter

FIG. 7 shows a diagram of a ground transmitter in accordance with a preferred embodiment of the present invention. The ground transmitter includes antenna subsystem 710, frequency conversion block 770, CDMA encode block 780, and processor 790. Antenna subsystem 710, in turn, includes antenna elements 720 and 730, phase shifter 740, signal splitting device 750 and amplifier 760.

The ground transmitter operates very much like the satellite transmitter with the exception that in general, a smaller number of polarized CDMA signals is being transmitted. CDMA encode block 780 encodes a data stream which is then input to frequency conversion block 770. As in the case of the satellite transmitter, the data stream input to CDMA encode block 780 represents data from one to multiple users. In the case of multiple users, CDMA encode block 780 spreads each user's data with a different pseudo-random code.

Antenna subsystem 710 could be any antenna subsystem capable of transmitting a polarized signal. As shown in FIG. 7, the preferred embodiment of antenna subsystem 710 includes two antenna elements 720 and 730, phase shifter 740, signal splitting device 750, and amplifier 760. Antenna elements 720 and 730 have an orthogonal component and in the preferred embodiment

being set forth, antenna element 720 is vertically polarized, and antenna element 730 is horizontally polarized, although they could be differently polarized.

The inclusion of processor 790 allows for the control of phase shifter 740 to introduce the desired polarization for the transmitted CDMA signal. One skilled in the art will appreciate that processor 790 provides a control function which can be implemented in a multitude of ways, including dedicated digital hardware, or a combined digital and analog control loop.

System Operation

FIG. 8 shows a flow chart for a method of operating a satellite transmitter in accordance with a preferred embodiment of the present invention. In step 810 a reference signal is CDMA encoded. The reference signal receives a unique spreading code known to all users so that it may be easily detected by receivers. After the reference signal is encoded in step 810, data signals are CDMA encoded in step 820. Each data signal receives a unique spreading code in accordance with well known CDMA techniques. In step 830, a polarization value is assigned to the CDMA encoded reference signal. Any polarization value is possible, but in the preferred embodiment a value of 0 is used. After the reference signal is assigned a polarization value in step 830, each of the CDMA encoded data signals is assigned a polarization value in step 840. The polarization values assigned to the CDMA encoded data signals are separated such that the polarization distance between adjacent signals is maximized. After step 840 is

complete, the CDMA encoded reference signal and data signals have polarization values assigned. Finally, in step 850, the CDMA encoded reference signal and data signals are transmitted with polarizations that were assigned in steps 830 and 840.

FIG. 9 shows a flow chart for a method of operating a ground receiver in accordance with a preferred embodiment of the present invention. In step 910, the ground receiver detects the reference signal as transmitted by the satellite. The reference signal is easily detected, because it is assigned a unique and well known spreading code. After the reference signal is detected, the polarization of the reference signal is measured in step 920. Once the polarization of the reference signal is known, the polarization of the desired CDMA signal can be found as shown in step 930. The polarization of the desired CDMA signal is found by summing the reference signal polarization with the known polarization offset corresponding to the spreading code of a desired CDMA signal. In step 940 the polarization network is modified to increase reception of the desired CDMA signal, and in step 950, the desired CDMA signal is de-spread.

In step 960, the signal quality of the received signal is measured. The signal quality measurement can be one of many different well known measurements, but it is preferably a code domain power measurement. A decision is made in step in 970 where, if the communications is continuing, the method loops back to step 940 where the polarization network can be modified to increase reception of the desired signal. This updating of the polarization network can occur periodically to continuously

compensate for changing faraday rotations caused by the ionosphere.

The methods of FIG. 8 and FIG. 9 depict the operation of the system in a general manner and the steps shown do not necessarily occur in the order shown. For example, in FIG. 8, step 820 can occur before 810, and in FIG. 9, step 970 can occur before step 960.

In summary, a system for employing polarization in combination with CDMA techniques provides for separation between users and decreases interference between users. Decreased interference increases the quality of communications and increases the capacity of the system, both of which are very desirable.

The foregoing description of the specific embodiments will so fully reveal the general nature of the invention that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing from the generic concept, and therefore such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments.

It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Accordingly, the invention is intended to embrace all such alternatives, modifications, equivalents and variations as fall within the spirit and broad scope of the appended claims.

CLAIMS

What is claimed is:

1. A transmitter for transmitting a plurality of signals comprising:

a polarization network which receives a plurality of CDMA signals; and

an antenna subsystem coupled to said polarization network, for transmitting a plurality of polarized CDMA signals.

2. The transmitter of claim 1 wherein said polarization network comprises a plurality of phase shifters for producing a plurality of phase shifted CDMA signals.

3. The transmitter of claim 2 wherein said polarization network further comprises:

a first signal summing device for summing said plurality of CDMA signals and producing a sum of CDMA signals; and

a second signal summing device for summing said plurality of phase shifted CDMA signals and producing a sum of phase shifted CDMA signals.

4. The transmitter of claim 3 wherein said antenna subsystem comprises:

a first antenna element having a first polarization, wherein said first antenna element transmits said sum of CDMA signals; and

a second antenna element having a second polarization, wherein said second antenna element transmits said sum of phase shifted CDMA signals.

5. The transmitter of claim 2 wherein at least one of said plurality of phase shifters has a programmable phase shift value.

6. The transmitter of claim 1 wherein said antenna subsystem comprises a plurality of antenna elements, and at least one of said plurality of antenna elements has a polarization different from at least one other of said plurality of antenna elements.

7. A receiver for receiving a plurality of signals comprising:

an antenna subsystem for receiving a plurality of polarized CDMA signals; and

a polarization network coupled to said antenna subsystem, for de-polarizing said plurality of polarized CDMA signals.

8. The receiver of claim 7 wherein said antenna subsystem comprises:

a first antenna element having a first polarization, wherein said first antenna element receives said plurality of polarized CDMA signals and produces a sum of first polarized component CDMA signals; and

a second antenna element having a second polarization, wherein said second antenna element receives said plurality of polarized CDMA signals and produces a sum of second polarized component CDMA signals.

9. The receiver of claim 8 wherein said polarization network comprises:

a first signal splitting device for splitting said sum of first polarized component CDMA signals and producing a plurality of first polarized component CDMA signals; and

a second signal splitting device for splitting said sum of second polarized component CDMA signals and producing a plurality of second polarized component CDMA signals.

10. The receiver of claim 9 wherein said polarization network further comprises:

a plurality of phase shifters for receiving said plurality of first polarized component CDMA signals and producing a plurality of phase shifted first polarized component CDMA signals; and

a plurality of summing points for summing each of said plurality of phase shifted first polarized component CDMA signals with one of said plurality of second polarized component CDMA signals to produce a plurality of de-polarized CDMA signals.

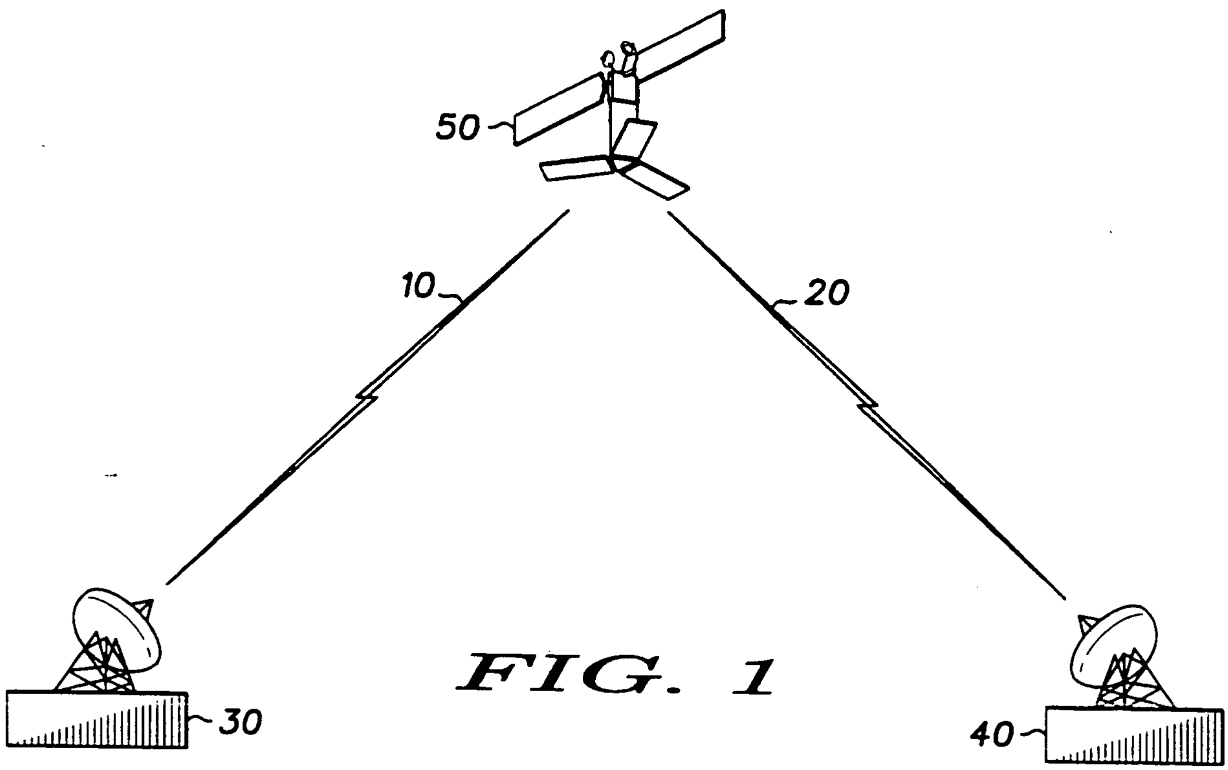


FIG. 1

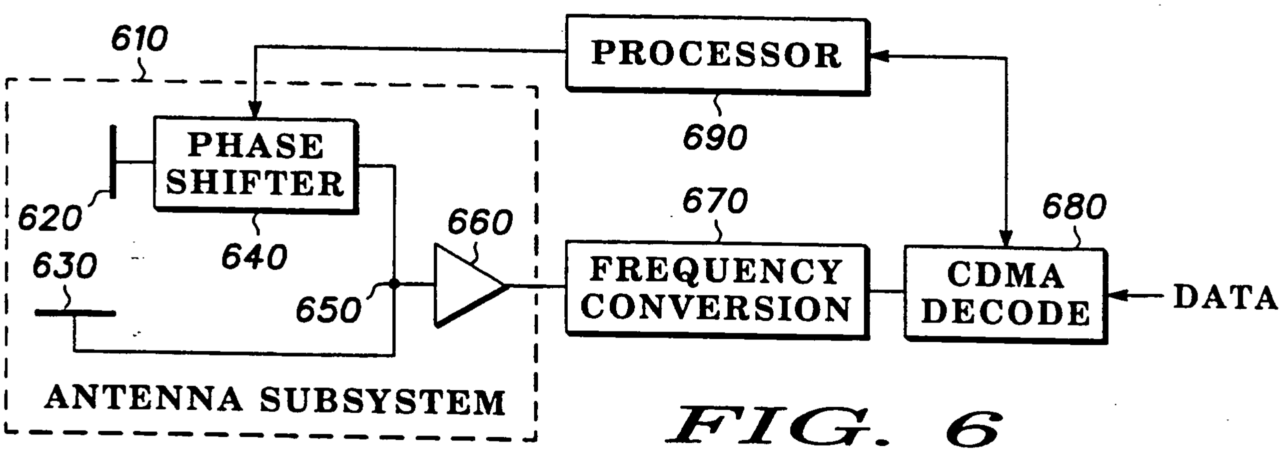


FIG. 6

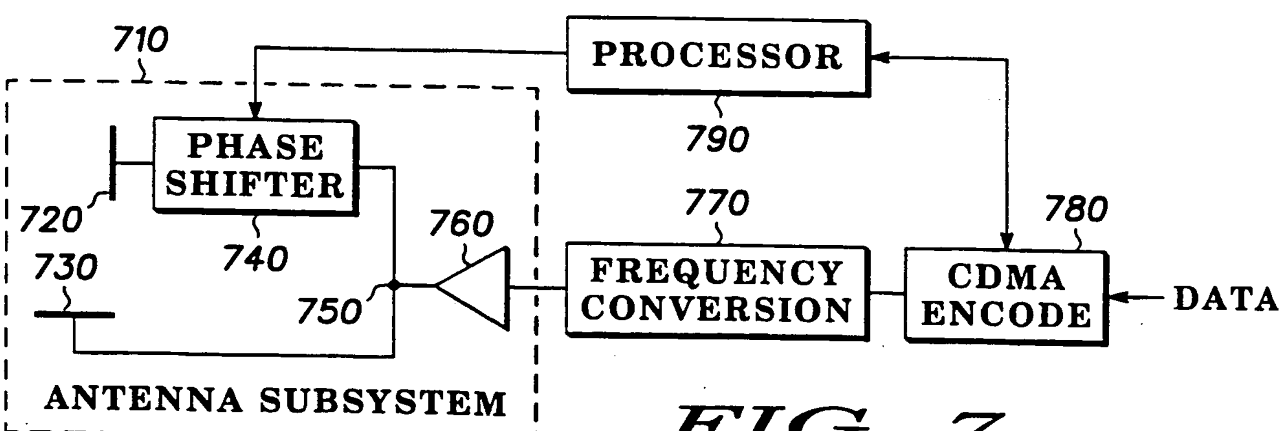
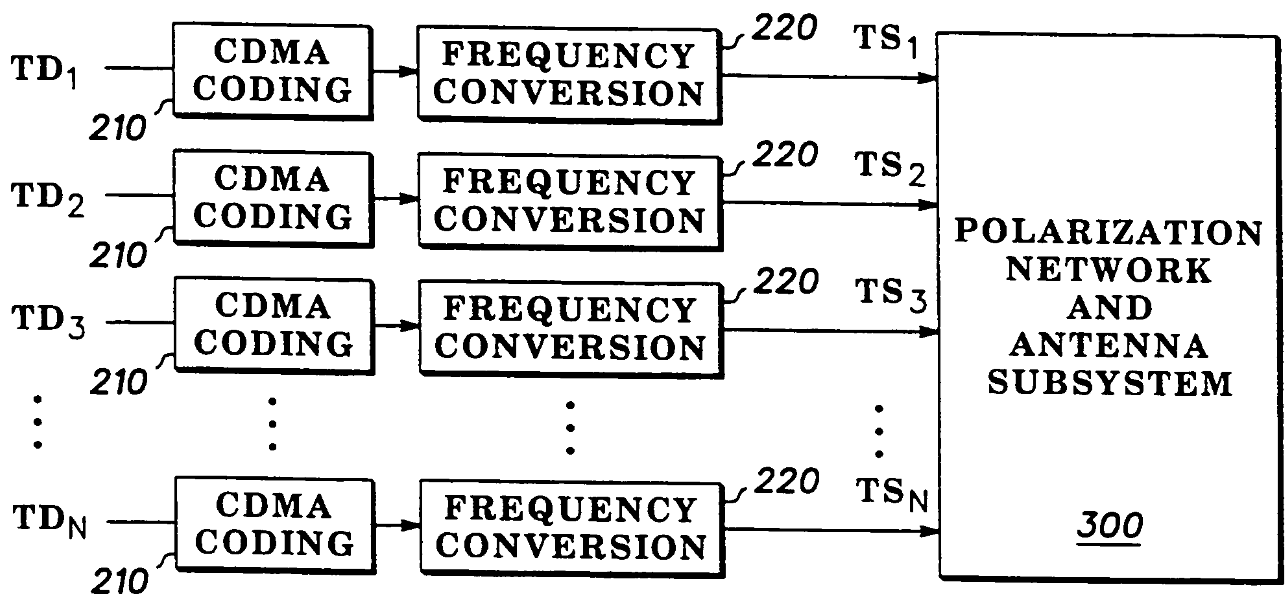
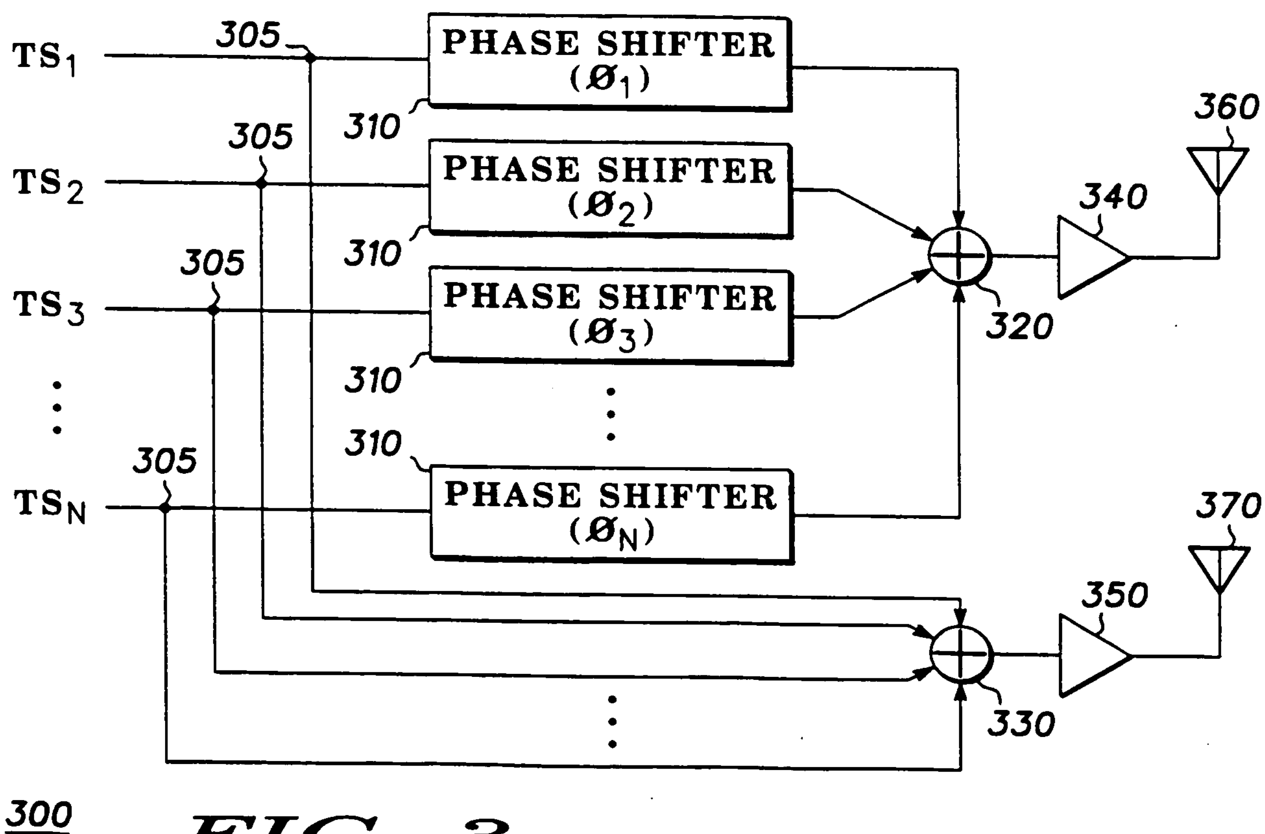


FIG. 7



TD1
TD2
TD3
TDN
CDMA CODING
FREQUENCY CONVERSION
210
220
TS1
TS2
TS3
TSN
POLARIZATION NETWORK AND ANTENNA SUBSYSTEM
300

FIG. 2



TS1
TS2
TS3
TSN
305
310
PHASE SHIFTER (Ø1)
PHASE SHIFTER (Ø2)
PHASE SHIFTER (Ø3)
PHASE SHIFTER (ØN)
320
330
340
350
360
370
300

FIG. 3

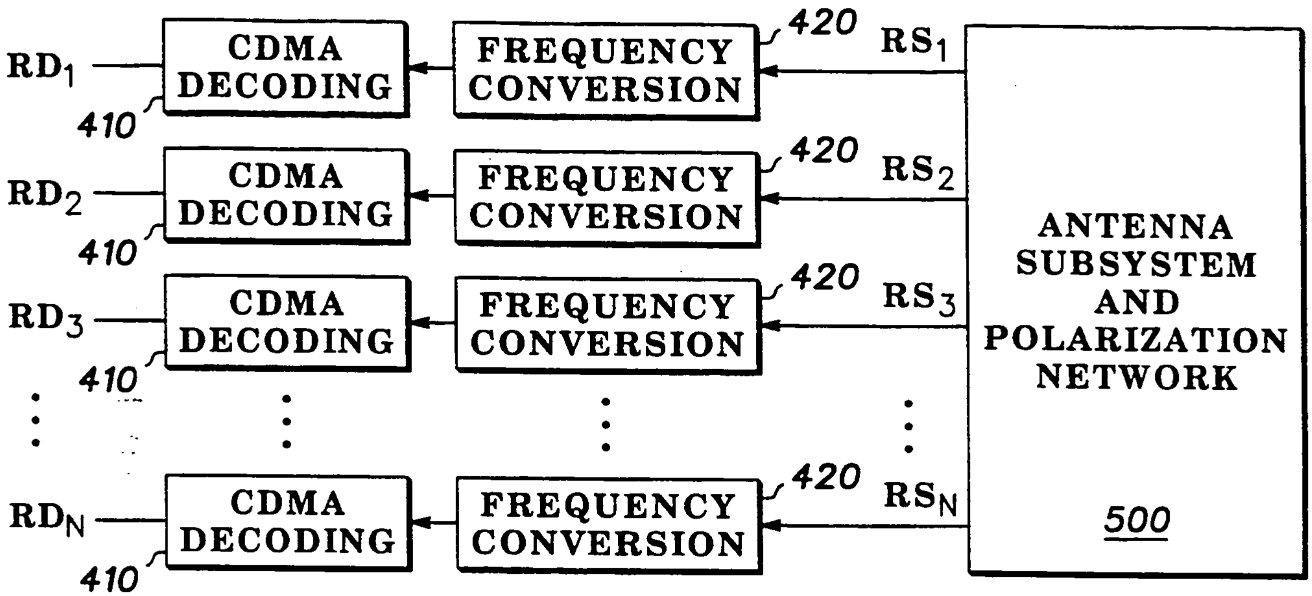
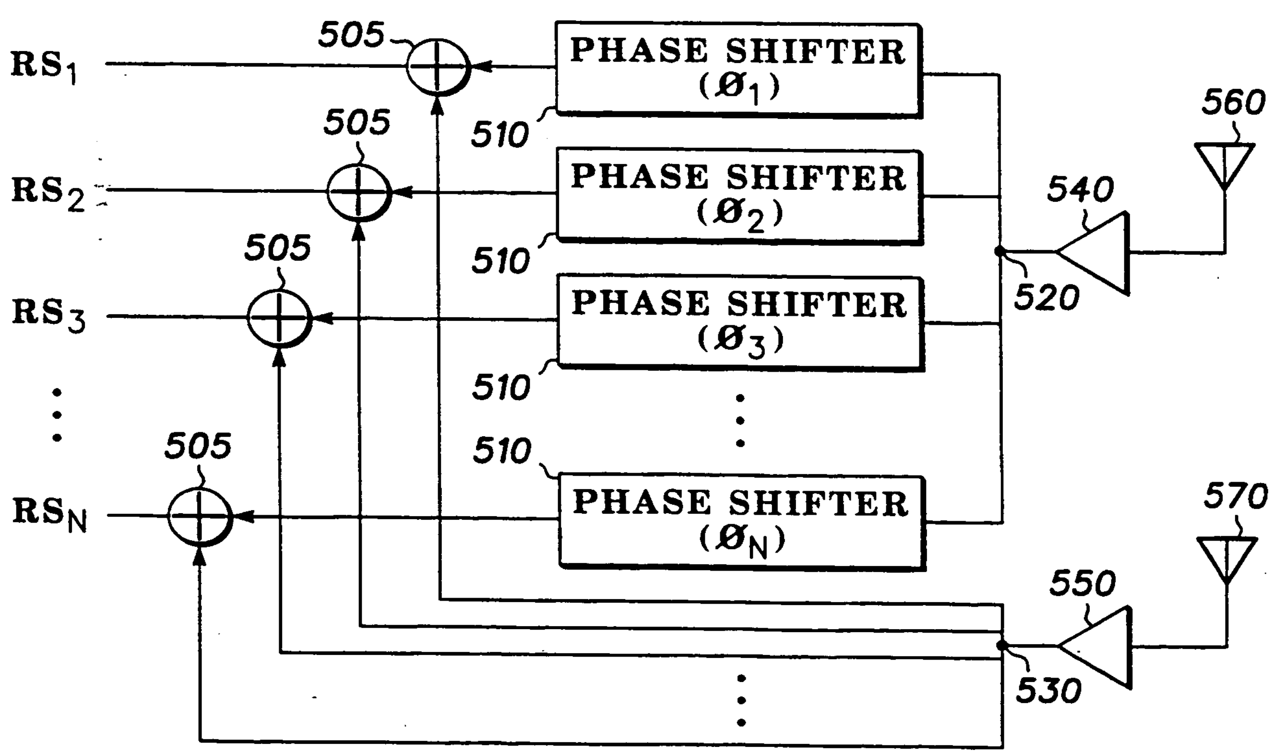


FIG. 4



500 FIG. 5

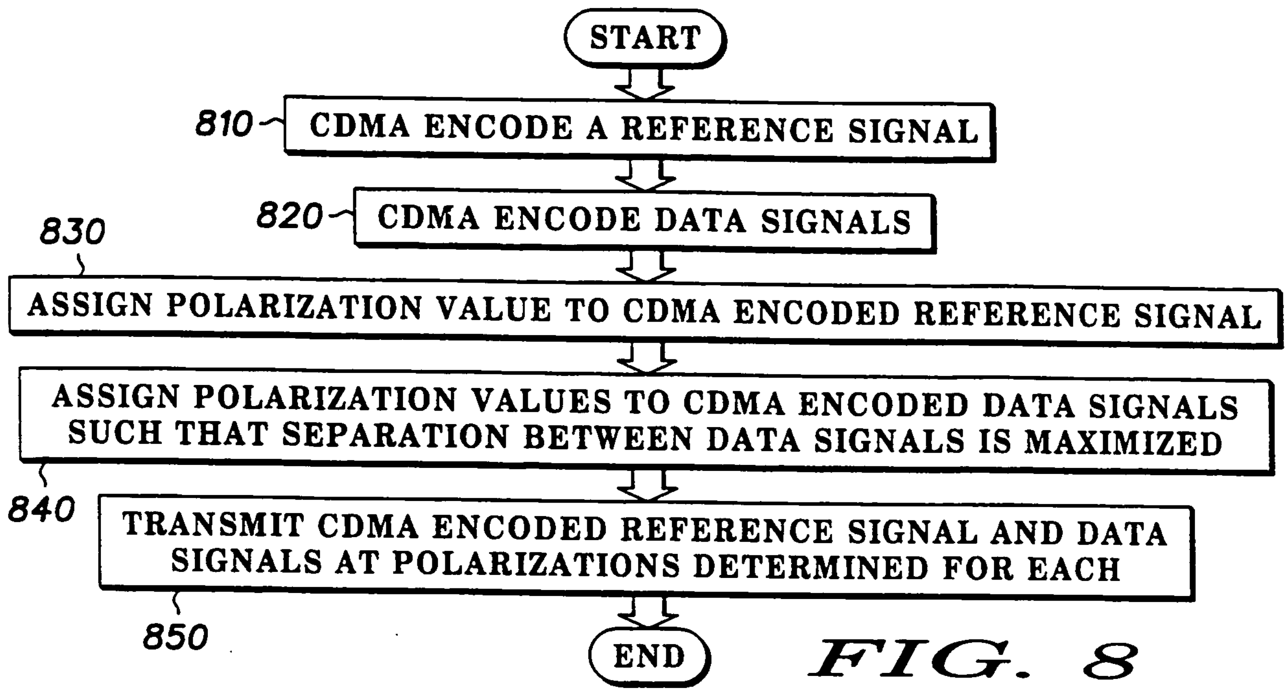

START
810
CDMA ENCODE A REFERENCE SIGNAL
820
CDMA ENCODE DATA SIGNALS
830
ASSIGN POLARIZATION VALUE TO CDMA ENCODED REFERENCE SIGNAL
ASSIGN POLARIZATION VALUES TO CDMA ENCODED DATA SIGNALS SUCH THAT SEPARATION BETWEEN DATA SIGNALS IS MAXIMIZED
840
TRANSMIT CDMA ENCODED REFERENCE SIGNAL AND DATA SIGNALS AT POLARIZATIONS DETERMINED FOR EACH
850
END

FIG. 8

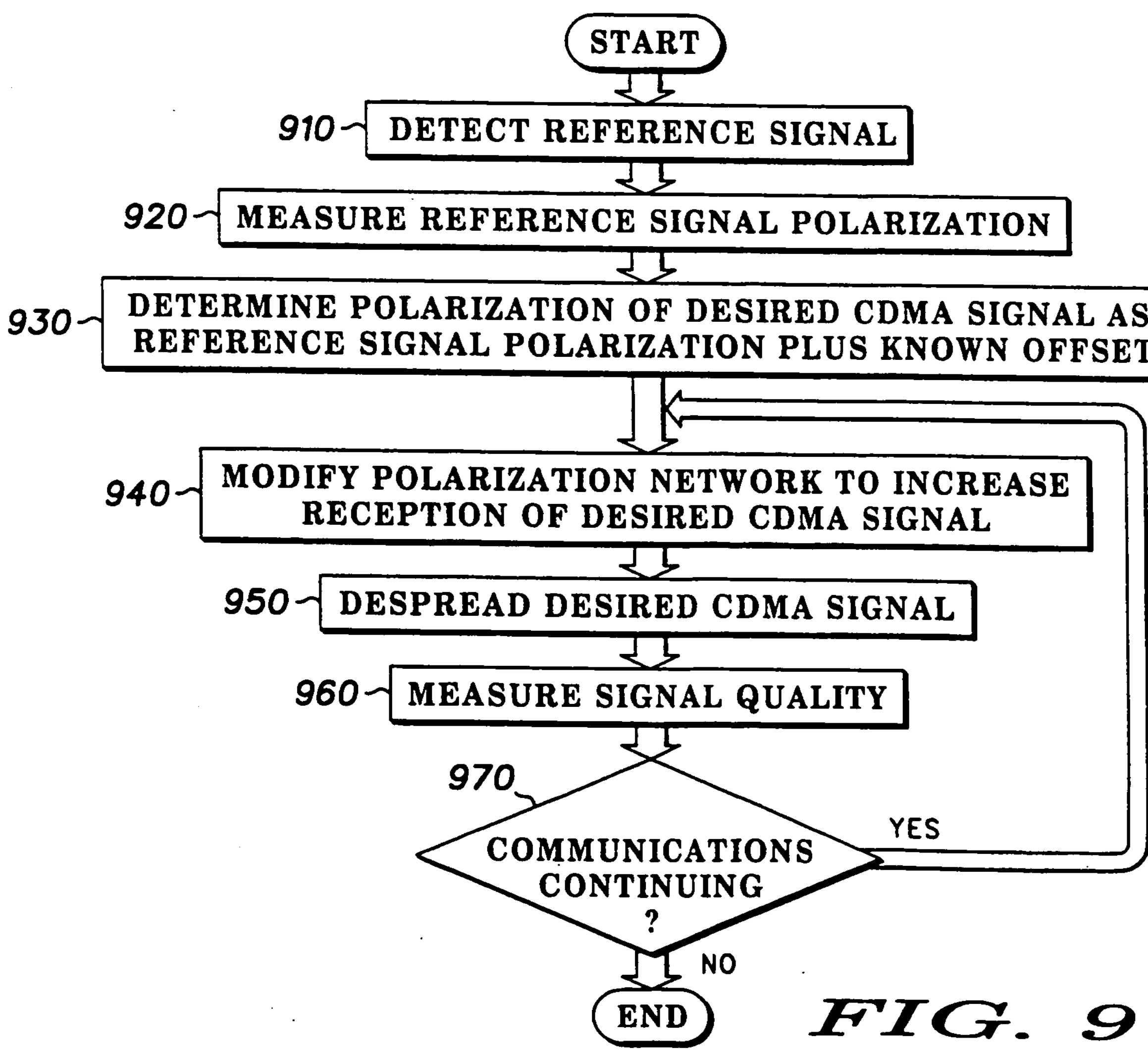

START
910
DETECT REFERENCE SIGNAL
920
MEASURE REFERENCE SIGNAL POLARIZATION
930
DETERMINE POLARIZATION OF DESIRED CDMA SIGNAL AS: REFERENCE SIGNAL POLARIZATION PLUS KNOWN OFFSET
940
MODIFY POLARIZATION NETWORK TO INCREASE RECEPTION OF DESIRED CDMA SIGNAL
950
DESPREAD DESIRED CDMA SIGNAL
960
MEASURE SIGNAL QUALITY
970
COMMUNICATIONS CONTINUING ?
YES
NO
END

FIG. 9

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/10885

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B7/10 H04B1/707 H04B7/26 H04B7/216

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 512 024 A (GUTLEBER FRANK S) 16 April 1985 see abstract see column 1, line 45 - line 68 see claims 1,2; figures 1,2	1-10
Y	EP 0 639 009 A (MATRA COMMUNICATION) 15 February 1995 see abstract see page 4, line 1 - line 18 see page 5, line 45 - line 53 see page 7, line 11 - line 28 see claims 1-4; figures 4,5	1-10
A	EP 0 715 478 A (TEXAS INSTRUMENTS INC) 5 June 1996 see abstract see claims 7,8,14; figures 9-12	1-10

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 September 1998	29/09/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lazaridis, P

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 98/10885

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 4512024	A	16-04-1985	CA	1200845	A	18-02-1986
EP 0639009	A	15-02-1995	FR	2709029	A	17-02-1995
			DE	69401404	D	20-02-1997
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			ES	2097620	T	01-04-1997
			FI	943606	A	14-02-1995
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EP 0715478	A	05-06-1996	EP	0796024	A	17-09-1997
			JP	10084306	A	31-03-1998
			JP	8237181	A	13-09-1996

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